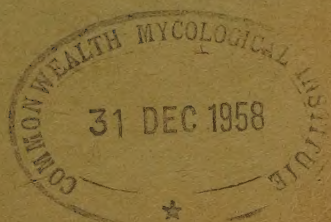
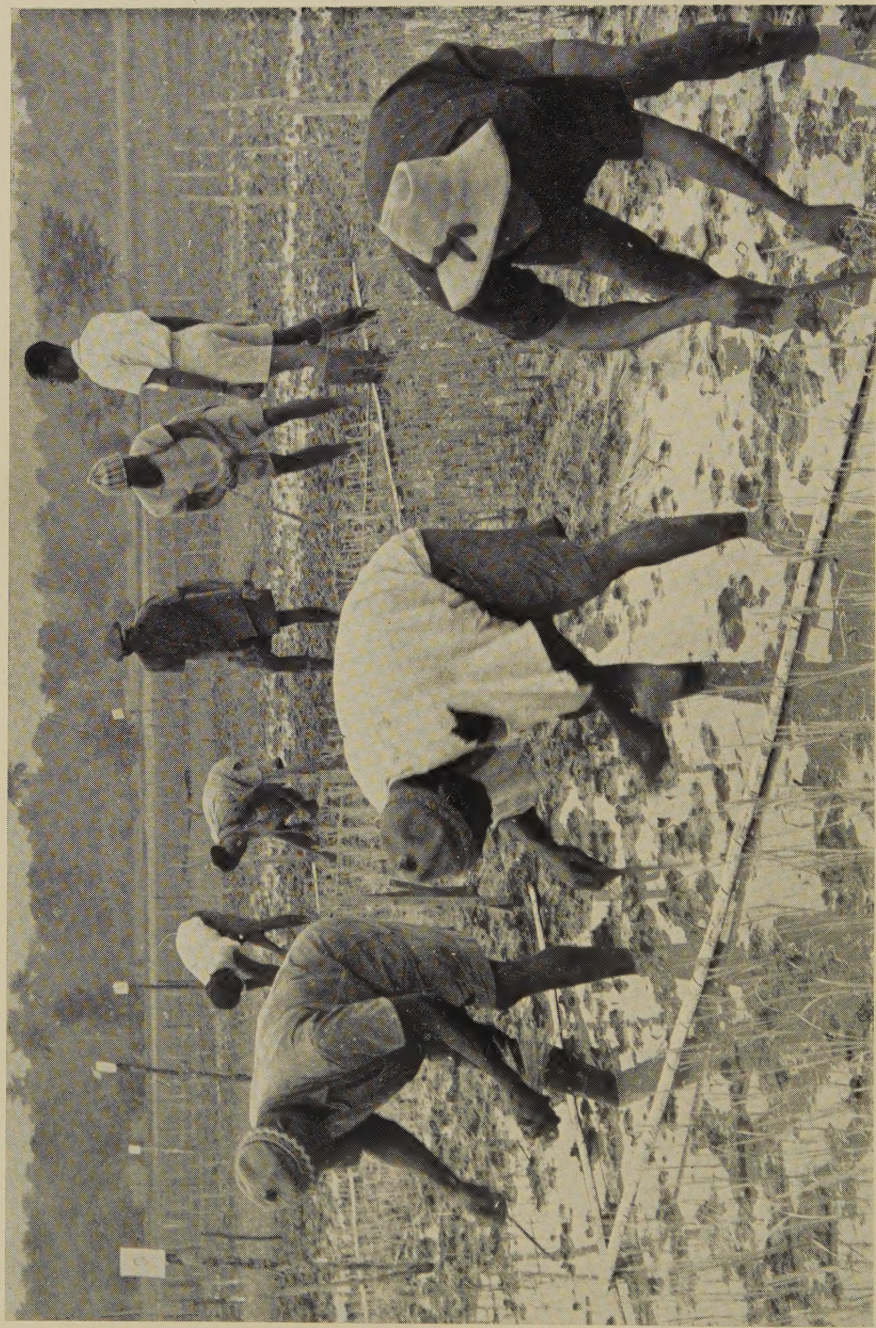


ANNUAL REPORT
of the
WEST AFRICAN
RICE RESEARCH
STATION

1957

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TRANSPLANTING A YIELD TRIAL AT MEASURED SPACING

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ADMINISTERING AUTHORITY
THE SIERRA LEONE GOVERNMENT

Director of Agriculture:

J. W. D. GOODBAN, O.B.E., M.A., DIP.AGRIC., A.I.C.T.A.

ADMINISTRATIVE AND PROFESSIONAL STAFF

At 31st December, 1957

Officer in Charge:

H. D. JORDAN, B.SC., A.R.C.S., A.I.C.T.A.

Botanists:

E. H. ROBERTS, B.SC., PH.D.

R. Q. CRAUFURD, B.SC.

DOROTHY L. ROBERTS, M.SC.

Soil Microbiologist:

M. G. R. HART, B.SC., PH.D.

Station Management:

J. C. RIPPEY, B.AGRIC.

INTRODUCTION

The West African Research Station at Rokupr continues to be administered by the Sierra Leone Government through the Director of Agriculture. It is financed by graded contributions from Colonial Development and Welfare funds and from the Governments of Sierra Leone, Nigeria, Ghana and the Gambia.

Although this year's report refers to investigational work having to be restricted because of staff leave, it is encouraging to record that steady and valuable progress is being achieved, and that, with general approval for the further staff expansion proposals put forward in 1956, greater continuity should become easier.

It is to be hoped that 1958 will see the completion both of the Research Station's principal facilities and, for the first time, a full staff in post as well as a welcome and more permanent simplification of financing. Already staff have, this year, been able to pay a greater number of visits to the other contributing territories outside Sierra Leone, and these will prove of inestimable value to all concerned in future investigations. It is the Research Station's policy to serve the requirements of all contributing territories, and, though because it is sited in Sierra Leone the field work has perforce to be restricted to "local" conditions, these are often directly comparable to those occurring elsewhere and the results of research can be readily adapted to them. This can be done more easily, the better the staff concerned know, as a result of their visits, what these conditions actually are.

Whilst the soils work has to date tended to be confined to salinity problems and to the lands reclaimed from mangrove swamps, the additional staff now coming forward, will also enable the pressing problems of inland swamps to be investigated. Breeding, selection and yield trials continue and should shortly allow some of the new proven varieties of rice to be issued for wider use.

J. W. D. GOODBAN,
Director of Agriculture.

ADMINISTRATION

STAFF

An increase in establishment of two research officers, a third Botanist and a further Soil Chemist, was approved in 1957, though it was only possible to fill the former post on a temporary basis towards the close of the year. Certain alterations in the strength of technical staff have also been made.

Administrative and Professional

Mr. H. D. Jordan resumed duty as Officer-in-Charge on his return from leave in mid-March and Mr. E. H. Nichols, Senior Agricultural Officer in the Sierra Leone Department of Agriculture, who had been acting as relief, then went on leave.

Mr. R. C. Knill, Agricultural Officer, was on the station for most of the year, but went on leave in early November when Mr. J. C. Rippey, Temporary Agricultural Superintendent in the Department of Agriculture was posted to Rokupr to take over from him.

In the continued absence of a Soil Chemist, Dr. M. G. R. Hart, Soil

Microbiologist, was the sole research officer in the Soil Science section and he was absent on leave from the beginning of June to the end of October.

In the Botany section, Dr. E. H. Roberts took leave at the beginning of January, returning in mid-May, and Mr. R. Q. Craufurd went on leave in early June and returned at the end of October. Mrs. D. L. Roberts was appointed on a temporary basis to the third post of Botanist and started work in mid-November.

With so many officers on leave during the year, there has been an inevitable slow down in the pace of the work during 1957.

Clerical and Technical

Clerical staff have continued to be at full strength, though this has only been possible by employment of temporary staff of lower qualification to fill vacancies. The position is thus still not perfectly satisfactory.

Three out of six posts of Laboratory Assistant have been filled and two further Assistants transferred from the West African Fisheries Research Institute on its closure early in the year. It is probable, however, that they will return to a reconstituted Fisheries Research Unit early in 1958.

The field staff position has remained satisfactory.

Unestablished Staff and Labour

The four posts of Laboratory Attendant, and ten of Farm Guard were full throughout the year as were those of artisans and minor employees.

Some reduction has been possible in the labour force which averaged 130 through the year.

PUBLICATIONS

The station has continued to issue cyclostyled Quarterly Progress Reports which briefly indicate the work in progress. The Annual Report for 1955 was received from the printers and distributed but the 1956 Annual Report was still in the press at the close of the year.

Numbers 2 and 3 in the series of cyclostyled Bulletins were issued. The first of these dealt with undeveloped mangrove lands in Sierra Leone and consisted of three surveys and map, and the second consisted of reports on rice growing in the Gambia and Portuguese Guinea.

Five papers, submitted in 1956, were published during the year. These were:

“Relationship between Mangrove Vegetation, Soil Texture and Reaction of Surface Soil after Empoldering Saline Swamps in Sierra Leone.” T. E. Tomlinson. *Tropical Agriculture*, 34, 41 (1957).

“Hybridization of Rice.” H. D. Jordan. *Tropical Agriculture*, 34, 133 (1957).

“A Seasonal Variation of the Surface pH value of some Rice Soils of Sierra Leone.” T. E. Tomlinson. *Tropical Agriculture*, 34, 287 (1957).

“Changes in Sulphide-containing Mangrove Soil on Drying and their Effect upon the Suitability of the Soil for the Growth of Rice.” T. E. Tomlinson. *Empire Journal of Experimental Agriculture*, 25, 108 (1957).

“Crabs as Pests of Rice on Tidal Swamps.” H. D. Jordan. *Empire Journal of Experimental Agriculture*, 25, 197 (1957).

A re-write of the crab paper, “Rice Destruction by Crabs”, has been accepted for publication in *World Crops* in March, 1958.

TOURING AND VISITS

Mr. H. D. Jordan attended the second meeting of the West African Standing Advisory Committee for Agricultural Research and the first meeting of its Rice Panel, which were held in Accra in early April. In September he spent three weeks in Ghana, visiting rice-growing areas in the Northern Province, Ashanti and the coastal South-west. This was followed by a brief visit to Sokoto and Birnin Kebbi in Northern Nigeria. The Sokoto river flood plain has deep water conditions and it is thought that floating rices of *Oryza sativa* species, such as are being grown successfully in the south of Sierra Leone, could be grown here in place of existing *Oryza glaberrima* varieties.

Mr. R. Q. Craufurd attended, as a United Kingdom delegate, the meetings of the various working parties of the International Rice Commission of the United Nations Food and Agriculture Organization held at Vercelli in Italy in September. This proved most useful in bringing the work at Rokupr to the attention of rice experts from other countries and considerable interest was shown in the lines of research in progress.

Dr. M. G. R. Hart attended a West African Soil and Plant Nutrition Conference in Accra at the end of March and followed this, after a quick visit to Northern Nigeria, by a ten-day tour of the Niger delta lands of the Eastern Region.

Dr. E. H. Roberts spent a week in French Guinea in November when he visited the experimental rice station at Kankan and various development schemes under partial irrigation on the riverain flood plains of Upper Guinea. It is thought that some at least of the work being carried out there may be applicable to similar conditions in Sierra Leone and Northern Nigeria.

Within Sierra Leone, visits were made by staff from time to time to mangrove areas and the riverain flood plains.

VISITORS

His Excellency the Governor of Sierra Leone, Sir Maurice Dorman, K.C.M.G., honoured the station by a brief call in March and, accompanied by Lady Dorman returned for a further visit at harvest time in December.

The Honourable D. L. Summer, Minister of Communications in the Sierra Leone Government, paid a brief visit during December.

Visitors from the United Kingdom included Mr. G. Lacey, Drainage and Irrigation Advisor to the Colonial Office, in January, Mr. J. E. Mayne, Colonial Liaison Officer at the National Institute of Agricultural Engineering, and Mr. D. Rhind, Secretary for Agricultural and Forestry Research at the Colonial Office, in March, Mr. K. Wilson-Jones, Secretary to the Colonial Pesticides Research Committee, in June, and Mr. D. W. Hall, Colonial Pest Infestation Liaison Officer, and Mr. V. F. Eastop of the British Museum, in August.

Mr. H. Reiner, American Consul in Monrovia, paid a brief visit to the station in November and there were a number of officers from other West African Territories at Rokupr in the latter part of the year. Dr. M. I. Ashrif, Agronomist at the Gambia Rice Farm, spent some weeks on the station from the end of October to mid-December, and Mr. H. Spencer Knott, Manager of the Lowland Rice Scheme in Northern Nigeria, and Mr. L. D. Sparnaaij of the West African Institute for Oil Palm Research, each visited for a few days during October. Mr. E. M. Nyenhuis, Senior Lecturer in Crop Production in the University College of Ghana, visited Rokupr in November, and Dr. W. K. Agble and Mr. J. McEwen, Plant Breeders in the Ghana Department of Agriculture, came in December as did also Mr. G. G. Williams, Agricultural Officer

in the Department of Agriculture of Northern Nigeria. It was possible to show these officers varying types of Sierra Leone rice lands in addition to the station itself.

Dr. G. W. Ivens of the Colonial Pesticides Research Unit at Arusha in Tanganyika paid a further visit to Rokupr for three weeks in April and May in connexion with work on herbicides and arboricides.

MANAGEMENT AND MAINTENANCE

BUILDINGS

Four Clerical and Technical Staff quarters were completed by the Public Works Department during the year. This completes the immediate programme, there now being fourteen new quarters and fifteen old ones which have been reconditioned.

With the approved increase in research staff, preparations have been made for three new Professional staff quarters and materials for these are being collected and sites prepared. Completion of these will give six new houses and three reconditioned old ones, one of which is retained by the Department of Agriculture for future staff posting.

Complete redecoration of one senior quarter was carried out and the offices and laboratories were decorated externally.

The Launch shelter at the town wharf has been dismantled and re-erected on the station and an access causeway is under construction.

SERVICES

The Sierra Leone Public Works Department continues to manage the station water supply. Water was again very dirty in the dry season and it is apparent that some form of filter bed will be necessary for use at that time of the year.

The station electricity supply is managed by the Sierra Leone Electricity Department and supplies the town of Rokupr. To cope with increased consumption in the town a third generating set has been installed from Sierra Leone funds.

VEHICLES AND MACHINERY

A long wheel-base Land Rover with station wagon type body was received in the latter part of the year and has been a most welcome supplement to the 3-ton Bedford lorry for road transport.

River transport continues to consist of the large diesel launch, and the small T20 runabout launch. The latter continues to give trouble.

A Ferguson tractor has been received and with a tipping trailer has been most useful for cartage of materials on the station. A gang mower has also been obtained and during the rainy season much of the station grass was cut with the tractor and mower.

The M.G.6 tractor, motor scythes and motor mowers have continued to be used for general farm work and station upkeep.

STATION UPKEEP

The repair to bunds and drains on the swamp farm has been completed.

Selective thinning of the station trees has been carried out and this has enabled the area which can be mown with the gang mower to be increased and thus reduced the cost of upkeep.

Further plantings of fruit trees for staff use were made at the beginning of the rains and the upkeep and recording of the Angola Oil Palm plantation has continued. These palms were inspected by officers from the West African Institute for Oil Palm Research and considerable interest is being shown in some of them as a source of seed.

EXTENSION AREAS

The first of projected station extension areas on differing types of rice land has been started. This is at Mando on the Little Scarcies river, where in a very small area it is possible to find three distinct environments: suitable for ordinary swamp rices; suitable for floating rices; and suitable for an out-of-season crop planted in December. Mando is within an hour by road from Rokupr and trials can easily be planted and supervised from the main station. The rice lands in this area are not tidal mangrove swamps but grasslands that flood from the river.

WEATHER

The year started with a very severe prolonged dry season. The harmattan wind blew strongly in January and the minimum temperature of 50° F recorded on 8th January is the lowest in 19 years records. No rain fell at all in the first three months of the year, there were only two heavy showers in April, and May had a record low rainfall. A normal June was followed by an exceptionally wet July and an August with rainfall over five inches lower than the previous low record. From September onwards the weather followed the normal pattern. It is the first year in twenty years' records that there has been a definite double peak rainfall. The total rainfall for the year was well below average. Temperatures in general were slightly below average. Full meteorological records for Rokupr for the year are given in the Appendix.

AGRONOMY

There were no changes in general nursery and planting practices which continued as described in earlier reports.

No major damage by crabs is reported, but despite spraying with a technical benzene hexachloride suspension there was minor damage to some parts of the farm—mainly near bunds and drains near the river. One yield trial, sprayed before and after transplanting had noticeable damage and a second yield trial was sprayed four or five times at few days interval, starting just before transplanting and was much less attacked. It is apparent that more frequent spraying round about the time of transplanting will be necessary for experimental material on some areas of the farm.

Yields were disappointing this year. Lower yields are reported throughout the whole river area and it is thought that this is partly due to the severe dry season which would lead to higher salinity of the tide water, and partly to the light rains of August. Table 1 shows yields of blocks used for multiplication as compared with the previous six years.

514 bushels (of 60 lbs. weight) of seed were produced as follows:

Toma 112	111 bushels
B.G. 79	90 "
Lead	85 "
Kavunginpoothala 12	66 "
Ngasein 57	49 "
India pa lil 46	26 "
D 99	25 "
Sughandi	25 "
Indo China 53	22 "
Bolo 108	15 "

This seed was all distributed within Sierra Leone by the Department of Agriculture.

Mechanical purity of the seed was again maintained at a high standard. For two varieties, Lead and Toma 112, this seed will be replaced next

year by the Genetic stock material which has now reached this multiplication stage. The other Genetic stocks, B.G. 79, D 99, Bolo 108, India palil 46, Kav. 12 and Indo-China 53, have not yet reached the stage of multiplication when they can replace the present stocks of seed. Single plant bagging of all these varieties continues, though Ngasein 57 has been omitted this year as it has been found to be genetically impure.

TABLE 1
Yields of multiplication blocks—1957
(in lbs. paddy per acre)

Block	1951	1952	1953	1954	1955	1956	1957
7	2,200	2,370	1,580	1,740	1,740	2,550	1,210
10	970	2,650	1,170	2,200	1,870	1,550	1,060
11	580	2,370	1,420	2,200	—	2,340	820
13	960	2,540	460	2,140	1,820	1,300	890
28	1,660	1,520	860	2,220	2,100	1,690	790
29	1,650	1,840	—	—	—	—	820
30	610	1,600	840	650	1,170	420	590
31	1,830	1,170	—	1,510	2,600	1,550	1,960
32	600	500	1,930	530	1,330	1,020	900
33	1,540	1,210	—	—	1,770	1,260	1,100
34	780	1,970	1,170	700	2,060	1,630	1,700
35	1,360	1,320	—	1,770	1,640	1,260	990
36	910	1,460	440	550	2,090	1,660	1,660
37	1,100	1,150	1,150	1,560	1,330	1,170	1,800
38	780	1,190	470	760	1,570	1,250	860
39	660	1,010	860	960	1,170	650	780
41	1,350	1,720	1,210	1,400	1,290	2,120	1,500
42	980	1,370	810	1,320	1,860	1,810	1,550
43	2,210	2,440	1,090	2,280	2,260	2,530	1,260
44	1,430	1,420	950	—	2,540	1,090	880
45	1,140	1,670	1,000	1,540	2,570	920	1,030
46	610	1,380	800	1,990	2,410	1,340	1,040
47	1,100	910	360	770	1,380	1,130	780
48	1,130	1,270	380	450	1,140	360	730
49	880	910	370	860	890	400	640
50	2,530	520	1,370	2,290	1,310	1,810	1,410
51	1,360	1,280	1,860	2,400	2,950	1,450	700
52	1,160	2,430	1,160	2,180	2,370	1,870	470
53	1,190	1,590	1,550	1,640	1,140	1,330	500
54	1,130	1,820	650	1,220	2,210	1,030	660
55	1,080	1,650	590	870	830	750	580
56	880	690	670	540	620	940	930

Note.—In 1951 and in 1953 crabs caused considerable damage.

ARBORICIDE AND HERBICIDE TRIALS

Dr. G. W. Ivens visited Rokupr in the early part of the year and made examinations of the trials laid down in 1956. The results of these examinations were included in the 1956 report. He laid down a few further trials on *Paspalum vaginatum* and on the small *Raphia* palm, *R. gracilis*. Further observations have been made on these trials by Rokupr staff and these are reported below. It has become difficult in many cases to identify the trees in the original experiments, more particularly as cutting has been carried out by the local population.

Avicennia nitida

Observations two years after spraying are recorded in Table 2.

Trees in two treatments, Nos. 4 and 11, have been cut down for firewood, as have many of the dead trees in other treatments. In the 1 per cent 2, 4-D (2, 4-dichloro-phenoxyacetic acid) treatment there is

no regrowth from the stumps, but in the $\frac{1}{2}$ per cent there is normal regrowth. No dead trees have fallen on their own and all dead wood has been removed by the local population. The trees recorded as partially dead have some branches dead and the tips of others without leaves. It is likely that these are now all recovering.

TABLE 2
The results of arboricide treatments on Avicennia nitida

Treatment	No. treated	Months after treatment				
		12		24		
		No. dead	No. probably dying	No. dead	No. partly dead	
Basal trunk sprays						
1 } Diesel oil { No frill	10	0	0	0	0	
2 } Frill	10	0	7	0	0	
3 } 2,4-D ester { $\frac{1}{2}$ %	10	0	0	0	2	
4 } in oil { 1%	10	0	0	—	—	
5 } No { 2%	10	2	0	2	2	
6 } frill { 4%	10	8	1	10	0	
7 } 2,4,5-T ester { $\frac{1}{2}$ %	10	0	0	0	0	
8 } in oil { 1%	10	0	0	0	0	
9 } No { 2%	10	0	0	0	0	
10 } frill { 4%	10	1	3	4	2	
11 } 2,4-D { $\frac{1}{2}$ %	10	1	8	—	—	
12 } ester { 1%	10	0	10	0	4	
13 } in oil { 2%	10	6	4	8	1	
14 } Frill { 4%	10	7	2	9	1	
A } 2,4,5-T ester { 1%	10	0	0	0	0	
B } emulsion Frill { 4%	10	0	2	0	0	
C } 2,4,5-T L.V. ester { $\frac{1}{2}$ %	10	0	0	0	0	
D } in oil { 1%	10	0	0	0	0	
E } No frill { 2%	10	0	0	0	0	
F } Amino-triazole { 2%	10	0	2	0	0	
G } in water Frill { 10%	10	0	2	0	0	
Spray applied to ground and pneumatophores						
H } CMU { 4 lb./acre	5	0	0	0	0	
I } { 20 lb./acre	5	5	0	5	0	
J } 2,4,5-T { $\frac{1}{2}$ lb./acre $\frac{1}{2}$ %	5	0	0	0	0	
K } in oil { 2 lb./acre 2%	5	0	0	0	0	
L } 2,4,5-T { $\frac{1}{2}$ lb./acre 0.1%	5	0	0	0	0	
M } emulsion { 2 lb./acre 0.4%	5	0	0	0	0	

L.V.—low-volatile (methyl iso-butyl carbinol) ester.

The observations confirm some of the conclusions that were drawn last year; that 2, 4-D has been more effective than 2, 4, 5-T (2, 4, 5-trichloro-phenoxyacetic acid); and that, with frilling, lower concentrations of 2, 4-D are effective. Trees partially affected by water based sprays of 2, 4, 5-T and Amino-triazole last year have made complete recovery. There has been some recovery also of frilled trees treated with

2, 4-D at 1 per cent concentration. The frilled trees treated with diesel oil alone that last year appeared to be dying have now completely recovered.

A 2 per cent application of 2, 4-D in diesel oil to frilled trees would now appear to be the most economical effective treatment.

Rhizophora racemosa

Table 3 shows the position two years after spraying. In general there has been little recovery from the treatments; only in a few cases was it noticed that the bark had grown back over the treated portion of the trunk and the tree was still surviving. Just under a quarter of the dead trees have fallen and many of these have been cut up and removed for firewood. In some cases fallen trees are still partially supported by surrounding living trees. The partly living trees are mainly those with untreated aerial roots reaching the ground; in most cases the main trunk and prop roots are dead and decaying and it is expected that many of these trees will fall in due course.

TABLE 3

The results of arboricide treatments on Rhizophora racemosa

Treatment	No. treated	Months after treatment			
		12		24	
		No. more than 90% dead	No. 50-90% dead	No. more than 90% dead	No. 50-90% dead
1 } Diesel oil { No frill	10	0	0	0	0
2 } Diesel oil { Frill	10	4	0	7	0
3 } 2,4-D ester { $\frac{1}{2}$ %	10	4	1	4	1
4 } in oil { 1%	10	1	2	4	2
5 } No { 2%	10	3	2	1	2
6 } frill { 4%	10	7	1	9	1
7 } 2,4,5-T ester { $\frac{1}{2}$ %	10	0	0	0	1
8 } in oil { 1%	10	0	3	5	1
9 } No { 2%	10	3	3	4	1
10 } frill { 4%	10	5	1	9	0
11 } 2,4-D { $\frac{1}{2}$ %	10	5	3	8	1
12 } ester { 1%	10	4	2	6	3
13 } in oil { 2%	10	4	4	9	1
14 } Frill { 4%	10	5	2	9	1
A 2,4,5-T emulsion Frill	10	1	0	1	0
B } 2,4,5-T L.V. ester { $\frac{1}{2}$ %	10	1	1	1	0
C } in oil { 2% No frill	10	0	2	1	1
D } Low volume 2,4,5-T { Frill	10	4	3	4	1
E } in oil 2% { No frill	10	0	1	5	1
F } 2,4,5-TP ester { 1%	5	0	0	0	0
G } in oil { 4% No frill	5	0	0	0	0

L.V.—low-volatile (methyl iso-butyl carbinol) ester.

These second-year observations underline the conclusions reached last year, that 2, 4-D has given the highest rate of kill and that frilling has increased the effectiveness of this chemical. With frilling, a low concentration of 2, 4-D can be used to give a high percentage kill.

Paspalum vaginatum

Following on last year's experiment, when Dalapon (dichloropropionic acid) at 40 and 80 lbs. per acre was shown to give complete kill of well-grown *Paspalum* and a rate of 20 lbs. per acre gave considerable kill with little regrowth, further experiments were carried out using lower rates of Dalapon and combining the treatments with burning and with cutting.

A dense area of old *Paspalum*, about 18 inches high, was chosen adjacent to last year's experiment, and rates of 5, 10, 15 and 20 lbs. per acre of Dalapon in 50 gallons of water per acre were used. Un-replicated plots of one two-hundredth of an acre each were either given no pretreatment, were cut close to the ground a week before spraying, or were set on fire two weeks before spraying, the dry leaves burning and only the stouter woodier stems surviving the fire. The results of observations of these trials are shown in Table 4. It is of interest to note that the burnt plots have been cultivated by a local farmer for 1958 planting: normally the heavy growth of grass has prevented any cultivation.

TABLE 4
The effect of Dalapon, cutting and burning on Paspalum vaginatum

Treatment				Percentage Reduction		
				Months after treatment		
				6	7	12
1	No pretreatment	5 lbs./acre Dalapon		25	20	0
2	"	10 "	"	60	25	0
3	"	15 "	"	95	90	25
4	"	20 "	"	100	95	50
5	Grass cut	5 "	"	0	0	0
6	"	10 "	"	5	5	0
7	"	15 "	"	50	20	15
8	"	20 "	"	50	30	20
9	Grass burnt	5 "	"	75	50	—
10	"	10 "	"	100	95	—
11	"	15 "	"	100	100	—
12	"	20 "	"	100	100	—

It is seen from these results that, while burning prior to treatment has enhanced the effect of the chemical, cutting has diminished its effect. Without any prior treatment a rate of 15 lbs. per acre of Dalapon has resulted in a high percentage reduction after six months, while, after burning, complete kill was recorded with a rate of 10 lbs. per acre and considerable kill with 5 lbs. per acre.

Raphia gracilis

The small thatch palm, *Raphia gracilis*, is an important constituent of fresh water swamps lying behind the mangrove areas, and on the fringe of saline influence in the rivers is often found mixed with mangroves, though these specimens are usually rather stunted. A trial was therefore laid down with 2, 4-D and 2, 4, 5-T butyl esters at 0.25 and 1 per cent in diesel oil. These were applied to isolated clumps of palms immediately after cutting the shoots to ground level, and one week after cutting when young shoots were sprouting. Table 5 shows results after one year.

It will be noted that only in one case, that of the palm clump treated with the lower concentration of 2, 4-D one week after cutting, has there

been appreciable regeneration. In all other cases—including that of the unsprayed clump—there has been death or regeneration only by a few weak shoots. These palms were all growing near the limit of their natural conditions, on tidal land which receives some saline flooding, and it is suggested that under these conditions any sharp setback in growth may result in death. The trial is worth repeating on well-grown palms growing under more natural conditions.

TABLE 5
The results of arboricide treatments on Raphia gracilis

Treatment			Number of living shoots per clump	
			At treatment	After 12 months
Control—cut only			35	3
Sprayed immediately after cutting				
1	Diesel oil		27	0
2	2,4,5-T ester in oil	0.25%	80	0
3	„	1.0 %	70	5
4	2,4-D ester in oil	0.25%	50	0
5	„	1.0 %	20	0
Sprayed one week after cutting				
6	Diesel oil		90	0
7	2,4,5-T ester in oil	0.25%	60	0
8	„	1.0 %	90	0
9	2,4-D ester in oil	0.25%	80	30
10	„	1.0 %	56	0

BOTANICAL RESEARCH

The work of the year has largely been the routine handling and observation of varieties in the improvement programme. Physiological experiments have been continued but, with staff shortage due to leave incidence, new lines of work have hardly been more than started.

INTRODUCTION AND TESTING OF RICE VARIETIES

A further forty-two new introductions were received this year in time for sowing and were planted in the observation collection. Thirty-three of these were varieties of *Oryza glaberrima* with floating habit which have been sorted from the local complex at the Nigerian Federal Rice Research Station. Unfortunately all these failed at Rokupr, where they were planted under atypical conditions for this type of rice. It is proposed to re-introduce these varieties and to grow them under deep-water conditions in the old experimental polders at Rokupr. The other nine varieties, all of *Oryza sativa* species, are as follows:

From Senegal	...	...	Makalioka 823
Java via Nigeria	...	...	Mas 2401
South Vietnam	...	...	Ba Monh T.1 S.6
			Nang Tay Nho CF.15
Madras	...	...	Kasama Red Asd.7
			Molagolukulu Bcp.2
			Pedhabasangi Mtu.4
			Bontha Krishna Katukalu Mtu.5
			Punasa Basangi Mtu.20

In addition a further ten local Sierra Leone rices, five of which are *O. sativa* and five *O. glaberrima*, were added to the swamp collection which now numbers 491. This year the collection was divided into two parts; 331 varieties were planted in plots of the normal size, 6 feet by 30 feet, for multiplication and observation; and 160 varieties, which are only required to be maintained, were planted in reduced size plots of 6 feet square. Two of the upland varieties were discarded and the remaining 29 planted as a small upland collection.

Fifteen rices were received from the Gambia Rice Farm. These were mainly samples of varieties originally sent to the Gambia from Rokupr. They arrived late in the season and it was only possible to sow them to maintain the seed. They will be grown in the collection in 1958 for comparison with the standard types.

Nine floating rices were duplicated in deep-water observation plots on the station extension area at Mando.

The records of the characters of most of these rices have now been transferred to punched cards and in future it will only be necessary to keep these up to date and to record new introductions.

Samples of a number of varieties as follows were sent to other countries on their request:

Ghana	66 samples
Nigeria	57 "
Gambia	54 "
Liberia	24 "
French Guinea	5 "
Hyderabad, India	8 "
Argentina	16 "

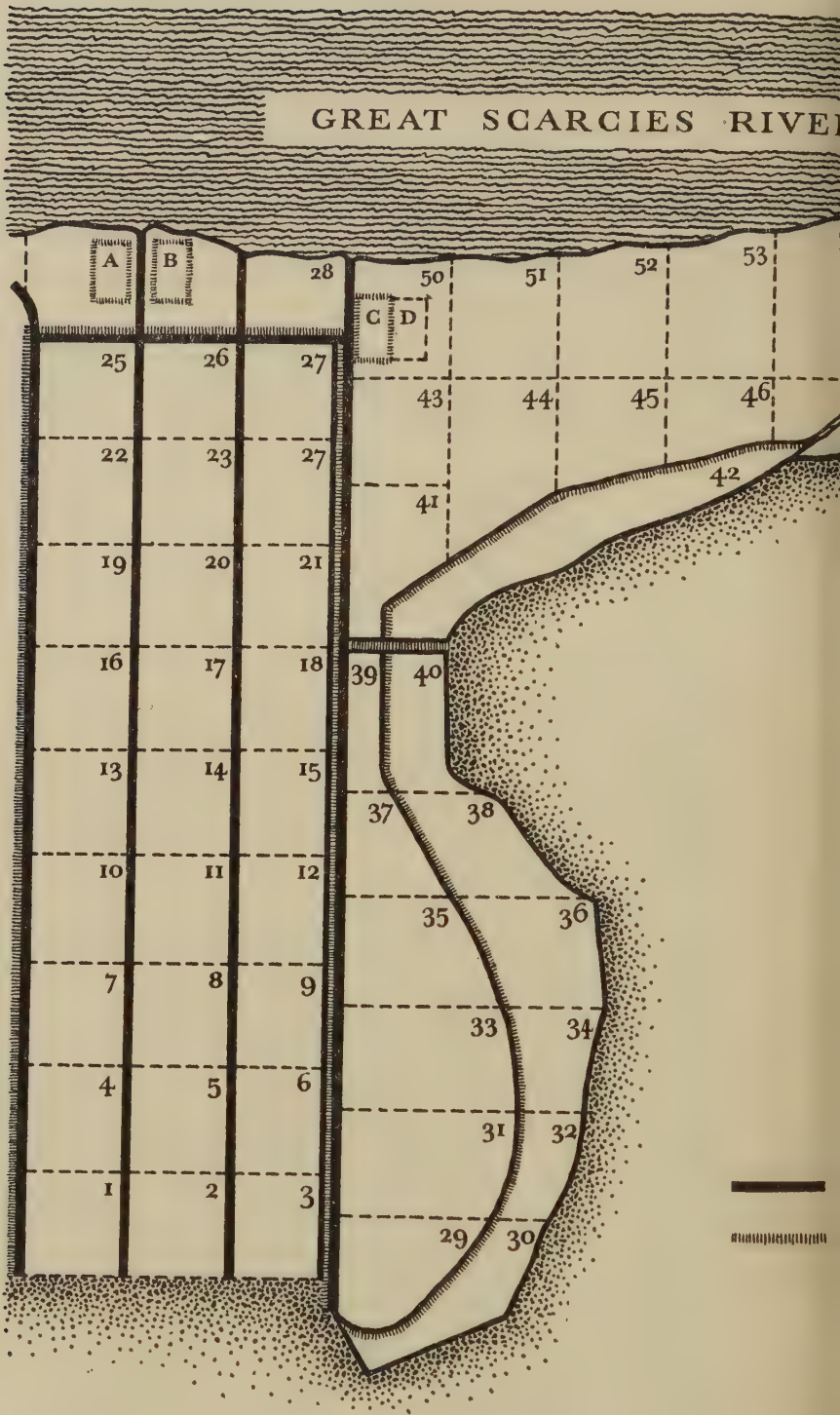
Promising Varieties

Long narrow plots (580 × 6 feet) were again used for the most promising of the recent introductions under observation and trial and their advantage over other shapes of plots confirmed. Handling of the crop was considerably easier and the effect of a fertility gradient could be assessed. One modification that was introduced this year was the separation of varieties of similar duration in order to minimize any possible cross-pollination.

Yields in general were lower than in 1956, reflecting the reduced yields throughout the farm. Four varieties gave yields of over 3,000 lbs. per acre; of these, Radin China 4 (from Malaya) has given consistently good yields over four years, and Ngascin Thidat C24-102 (from Burma) has given good yields in three out of four years; Pai Gazo (from North Borneo) has only been grown for two years and has given good yields in both, but the fourth variety, Seri Raja (from Malaya), which has also been grown for two years, did not appear outstanding last year. A further thirteen varieties gave yields this year which were good for the season: in addition to those mentioned in the last report these include Mayang Ebos 80, Serayap and Reyong 6 from Malaya, Sokotera from Zanzibar, Raminad from the Phillipines, Parn A-191 from Thailand, Gantang from North Borneo and H.R.8 from Hyderabad.

Four full-sized statistical yield trials and three miniature trials were laid down at Rokupr. One of the large and two of the small trials gave no significant results. Two of the successful large trials repeated those of last year, and the successful small trial was a further repetition of one of them. It is intended to run all yield trials for three years and to use combined analysis on the results. This year a combined analysis for two years was attempted, but it was apparent that two years is an insufficiently long period to give an estimate of the variation in yield due

ROKUPR FARM: PL





<i>Block</i>	<i>Variety</i>
1	Genetic stocks (D 99 and Lead)
2	Selections
3	Collection and Hybrids
4	Genetic stocks (Bolo 108), Wag Wag and Selections
5	Genetic stocks (Sughandi), Promising Varieties and Selections
6	Hybrids
7	Indo-China 53
8	Genetic stocks (Lead) and Promising Varieties
9	Collection
10	Genetic stocks (Kav. 12)
11	Genetic stocks (Toma 112) and Promising Varieties
12	Collection
13	Kav. 12
14	Genetic stocks (Toma 112) and Promising Varieties
15	Collection
16	Promising Varieties
17	Promising Varieties
18	Collection
19	Promising Varieties
20	Promising Varieties
21	Collection
22	Promising Varieties
23	Promising Varieties
24	Yield Trial and B.G. 79
25	Promising Varieties
26	Promising Varieties
27	Yield Trial, Experiments and Lead
28	Indo-China 53
29	Genetic Stocks and Ngasein 57
30	Kav. 12
31	Yield Trial, Experiments and B.G. 79
32	Kav. 12
33	Yield Trial and B.G. 79
34	Kav. 12
35	Lead
36	Kav. 12
37	Lead
38	Kav. 12
39	B.G. 79
40	B.G. 79
41	B.G. 79
42	B.G. 79
43	Yield Trials and Lead
44	Lead
45	Lead
46	Lead
47	Lead
48	Lead
49	Lead
50	Indo-China 53
51	D 99
52	D 99
53	D 99
54	D 99
55	Lead
56	Lead
A	Sughandi
B	Sughandi
C	Sughandi
D	Sughandi
X	Sughandi
Y	Sughandi

to seasons. The miniature trials are for comparison with the full-scale trials, and to see whether this system will be of value in the future.

Last year a trial of early varieties showed no significant difference between the yield of the standard variety Lead 35 and that of any other variety. This year three varieties, Maung Nyo B24-92 (from Burma), Acheh Puteh (from Malaya) and Faya (from Nyasaland) all gave highly significantly greater yields than Lead 35, although showing no significant differences among themselves. Details of this experiment are given in Table 6.

TABLE 6

Yield trial of early varieties

Layout 6 × 6 Latin square.

Plots 15 × 13 feet planted at measured 6 inch spacing 2 plants per stand.

Area of plot harvested .0033 acre.

<i>Variety</i>	<i>Mean yield in lbs./acre</i>
Maung Nyo B 24-92	1,715
Acheh Puteh	1,682
Faya	1,677
MLY B 404	1,411
MLY C 401	1,193
Lead 35	1,186
Critical difference (5%)	291
Critical difference (1%)	397
Coefficient of variation	16.3

This trial was repeated in miniature. The coefficient of variation was large on the small plots and, while the first three varieties were the same as the first three in the large experiment (though in a different order), only Faya significantly outyielded Lead 35. Details are given in Table 7.

TABLE 7

Miniature yield trial of early varieties

Layout 6 × 6 Latin square.

Plots 6 × 3 feet planted at measured 6 inch spacing 2 plants per stand.

Area of plot harvested .00023 acre.

<i>Variety</i>	<i>Mean yield in lbs./acre</i>
Faya	3,234
Acheh Puteh	3,144
Maung Nyo B 24-92	2,678
Lead 35	2,531
MLY B 404	2,417
MLY C 401	2,156
Critical difference (5%)	697
Coefficient of variation	21.6

In a trial of early maincrop varieties in 1956 the standard variety Sughandi was used and no other variety had a significantly higher yield. Unfortunately this year the seed of this standard failed and B.G.79 was

therefore used as standard to replace it. Only one variety, Radin China 4 (from Malaya), gave a significantly higher yield than B.G.79. Details of this experiment are given in Table 8.

TABLE 8

Yield trial of early maincrop varieties

Layout 6×6 Latin square.

Plots 11×11 feet planted at measured 6 inch spacing 2 plants per stand.

Area of plot harvested .0019 acre.

Variety	Mean yield in lbs./acre
Radin China 4	1,341
Subang Intan 117	1,226
Reyong 6	1,223
Anak Didek	1,190
Radin Siak 34	1,119
B.G. 79	930
Critical difference (5%)	342
Coefficient of variation	14.7

The third full-scale trial compared five further early maincrop varieties with two standard varieties, an early rice D99 and a maincrop rice Toma 112. Details of yield are given in Table 9. Parn A-191 gave a significantly higher yield than all other varieties, and Anak Didek (from Malaya) gave a highly significantly lower yield.

TABLE 9

Yield trial of early maincrop varieties

Layout 7×7 Latin square.

Plots 12×12 feet planted at measured 6 inch spacing 2 plants per stand.

Area of plot harvested .0023 acre.

Variety	Mean yield in lbs./acre
Parn A-191	3,351
Toma 112	2,954
Siam 9	2,941
Radin Siak 34	2,770
Nachin 11	2,748
D 99	2,635
Anak Didek	2,211
Critical difference (5%)	342
Critical difference (1%)	413
Coefficient of variation	10.0

One trial which was laid down on the station extension area at Mando failed to give any significant result.

Assistance was again given to the Sierra Leone Department of Agriculture in carrying out a yield trial on the central riverain flood plains under mechanization. Six promising varieties and six standard varieties were again included. Two of the standard varieties were varieties reported locally popular and local seed was used which failed to germinate. These have therefore been omitted from the results which are shown in Table 10.

TABLE 10

Yield trial on riverain flood plains

Layout Randomized Block 4 replications.
 Plots 220 yards $\times$ 11 feet 8 inches combine drilled at 50/60 lbs./acre seed and
 200 lbs./acre superphosphate.
 Area of plot harvested .18 acre.

<i>Variety</i>	<i>Mean yield in lbs./acre</i>
Nachin 11	627
Haji Haroun	615
Radin Siak 34	562
S India pa lil 46	511
Parn A-191	507
Pindosein A 29-20	493
S Sughandi	469
S Lead	414
S Toma 112	411
Faya	313
Critical difference (5%)	101
Critical difference (1%)	146
Coefficient of variation	15.2

S—Standard variety.

Yields were in general much lower than on the similar trial in 1956. There were no significant differences in yield shown between the remaining four standard varieties, but Nachin 11 and Haji Haroun, both from Malaya, showed significantly greater yields than any of them, this being at the 1 per cent level in the case of two of them. Radin Siak 34 was the next best and showed high significance in yield as compared with two standards. Faya gave a highly significantly lower yield than the other two.

No further work was carried out with uniformity trials as it has been decided that their use with analysis of covariance is not worth while and that three consecutive years' trials will give more information.

Milling Experiments

No further work was carried out with the Minghetti mill this year, as the fan and heater which were ordered for the drier did not arrive in time.

Palatability and Cooking Quality

Towards the close of the year a start was made on investigating a number of the standard methods for estimating cooking quality and palatability, and it is intended to test some of these methods against the results obtained with a local tasting panel.

SELECTION OF IMPROVED RICES

New Selections

Ngasein 57, which itself is an earlier selection from the Burma rice Ngasein C 19-26, has been showing signs of genetic variability and one hundred single panicle selections were made for examination as single panicle cultures in 1958.

First Year Selections

Six of the 13 selections of Panianala made last year were retained after examination of the field characters. Four of the 13 selections of Meike were similarly retained.

The single panicle selected from Tisei in 1956 appears to be pure and all seed has been retained for multiplication in order that it may be tested against other floating varieties.

Second Year Selections

Nine out of 19 selections of Kurulutuduwi b.13 were retained after this year's observations.

Third Year Selections

Three selections of Kema and one selection of Lath were discarded as impure. The remaining selections will be maintained for testing for tolerance to submergence. The experimental tank for this purpose is expected to be built in time for the 1958 season.

Fourth Year Selections

Four Mbagboli selections remain and final testing of these will be carried out under deep-water conditions in the proposed experimental tank.

The five selections of D.99 have shown no detectable differences from the Genetic stock of this variety and have been discarded.

Older Selections

One of the B.G.79 selections was discarded and the remaining three, as well as the two Kalimodu selections, are being maintained. No further work was carried out on these during the year.

The few remaining older selections were also maintained. Of these, it is hoped to be able to test the Pokkali selections for salt tolerance under controlled conditions shortly, and to observe the behaviour of the Indo-China selections as compared with other floating rices in the deep-water tank.

HYBRIDIZATION

No new crosses were made this year. It had been hoped to attempt crosses between the Nigerian floating *Oryza glaberrima* varieties and floating *O. sativa* varieties, but the failure of the former has meant that this programme has had to be postponed.

Hybrids in the F1 generation

Following on the decided policy, which was briefly mentioned in the last report, the seed from the four crosses made last year was multiplied and no selection made. These four crosses are:

- X (56)2 Bolo 108 × Ngasein 57
- X (56)3 Toma 112 × Indo-China 53
- X (56)5 India pa lil 46 × Elon Elon
- X (56)6 India pa lil 46 × Mayang Ebos 80

Hybrids in the F4 generation

X (53)1. Indo-China 53 × Indo-China 24. Observations on the pedigree lines of this cross between two selections of floating rices were made this year and as a result seven lines were discarded and ten plant selections made from the remaining lines.

Hybrids in the F6 generation

Selections made last year were again grown in pedigree lines and full observations made. Resistance to *Piricularia oryzae* in the nurseries was included among the criteria on which selection was made and plants were selected as follows for growing in pedigree lines in 1958:

- X (51)1 Yenti × DC 39/15—13 plants
- X (51)4 Ngasein 57 × Tai Chu 65—7 plants
- X (51)5 Toma 112 × Ngasein 57—4 plants
- X (51)7 India pa lil 46 × Kav. 12—14 plants

The material is showing very little segregation within the panicle rows and in the coming season, after single plant selections have been made, the rest of the rows will be harvested and bulked for milling and other tests.

Natural Cross Fertilization

Although the experiment laid down in 1956 was not satisfactory, an experiment using the same design at the rice station at Koba in French Guinea gave a useful result. It was therefore decided to continue planting a similar design at Rokupr over a number of years in order to investigate the variation in percentage natural cross-pollination. A further experiment was therefore laid down.

This particular design of experiment was developed in order to estimate the percentage of hybrid offspring produced by a plant grown in a typical plot, and it involves planting a pattern of plants of B.G.79 and Lead so that each Lead plant is surrounded by an equal number of B.G.79 and Lead plants at equal distances. The seed from the central Lead plants will be sown in 1958 and the number of seedlings having a purple pigmented sheath—a dominant character present in B.G.79 but not in Lead—will be counted and compared with the number of seedlings having no pigmentation.

The design of the experiment just described does not, however, give any information about the distances over which one can expect natural cross-pollination to occur. In order to obtain information about this, a second experiment was laid down using the same varieties. In this experiment a single plant of B.G.79 was surrounded by rows of Lead plants. The offspring seedlings of the Lead plants will be examined in 1958 for the presence of a pigmented sheath.

PHYSIOLOGICAL WORK

Factors affecting the Duration of Rice Varieties

The results of the 1956 experiments were fully examined and analyzed and the preliminary conclusions which were summarized in the last report were confirmed. No further work was carried out during the year, but an integrating photometer has now been obtained and a full programme in continuation of this investigation is planned for 1958.

Water relations of the Rice Plant

A start was made towards the close of the year on what is intended will become an important part of the research programme. In West Africa rice is grown very largely under natural water conditions, and it is thought that a thorough knowledge of the water relations of the rice plant at all stages of growth will be of considerable practical importance.

In the first instance it has been decided to concentrate on investigating the minimum requirements of germinating seeds and young seedlings and their drought resistance when short periods of wetting are separated by varying periods of dessication. Techniques are being worked out to

test varietal differences in drought resistance. This work should have a practical application in those areas in all the West African territories where swamp rice is sown under rather dry conditions and germinated by erratic rainfall.

Dormancy of Rice Seed

In due course it is hoped to speed up the breeding programme of the shorter duration rices which are relatively insensitive to photoperiod by growing two generations a year. The majority of varieties, however, and certainly all those which have been investigated at Rokupr, have a seed dormancy period: varieties usually take between two and three months to reach maximum germination after harvest. This characteristic makes it difficult to grow two generations a year of those lines which have durations of more than 150 days. Work was therefore started in 1956 to investigate factors which influence this dormancy period and to find a convenient method for speeding up the breaking of dormancy. Several methods for doing this have now been discovered and will be reported on separately after further investigation. The two most promising methods from the practical point of view are treatment with heat and with oxygen. Considerable decreases in the dormancy have been achieved by storing at high temperatures, but the optimum temperature is not yet known. The effect of combining oxygen treatment, which by itself can reduce the dormancy period by about a half, with heat treatments also remains to be investigated.

A study of the dormancy periods of the varieties in the collection at Rokupr has continued, and the preliminary results from more than 130 varieties suggest that there is no correlation between duration from sowing to flowering and the dormancy period. This is contrary to some suggestions by previous workers.

Seed Dressings

It was reported last year that, when Agrocide Dispersable Powder (containing technical benzene hexachloride) was used as a seed dressing, characteristic abnormalities developed in rice seedlings if the seeds were set to germinate after two months' storage. These deformities became more severe the longer the seeds were stored.

Further investigations have now been carried out using the pure gamma isomer of BHC, and it has been shown that when seedlings are grown in solutions of this substance the same symptoms develop as when seed is germinated after storage with Agrocide used as a seed dressing. Seeds which have been stored in Agrocide (1 gram per 8 ozs. of seed—which gives a weight ratio of gamma-BHC to seed of 1:3,488) for nine months show symptoms on germination which are equivalent to those produced in undressed seed grown in solutions of between 28.4 and 284 parts per million of gamma-BHC. It appears, therefore, that when rice seed is stored in BHC, the gamma isomer, and possibly other isomers, is absorbed by the seed until a level is reached which causes deformities.

The type of deformity produced, together with a recent suggestion by MacLagan that BHC might act as an auxin under certain circumstances, suggested that the deformities in rice seedlings might also be due to auxin activity of BHC. Further experiments were therefore carried out in which a comparison was made between the effects of gamma-BHC and various substances which are known to have auxin activity. These investigations showed, however, that apart from inhibition of root growth at the same order of concentration, there were no similarities between the effects of gamma-BHC and substances with auxin activity.

These latter substances had additional properties not shown by gamma-BHC and at appropriate concentrations caused the production of an epicotyl and reversals of coleoptile geotropism.

The full details of this work will appear in separate reports.

DISEASES

Piricularia oryzae occurred as usual in the nurseries. The attacks in general were unimportant except for the variety Sughandi and some late-planted observation varieties which were badly damaged. *Helminthosporium oryzae* also occurred as usual in the nurseries but did no damage. These two fungi cause the only two serious diseases of rice in the seedling stage so far reported from West Africa. There is very little information on either of them under West African conditions and an investigation was therefore begun into the weather conditions affecting the spread of *Piricularia oryzae* through the varietal collection nurseries.

The first attacks were recorded on the 13th day after sowing and fresh attacks were noted up to the 31st day after sowing. The recorded attacks rose to a peak number on the 19th day and then declined, but rose again to a second, higher peak on the 25th day and then declined again. These two peaks are thought to represent the primary and secondary infections respectively. Unfortunately the thermohygrograph failed at a critical time during the experiment, and information on the continuous changes of humidity and temperature was not obtained. It is thought, however, from the ordinary meteorological observations, that the weather conditions were near optimum for the spread of this disease during the nursery period.

It is intended to continue these observations through the next season and to extend them to include *Helminthosporium oryzae*.

Ephelis pallida occurred only on a local variety, Kani Ngoihun, in the collection.

SOIL SCIENCE

The study of the characteristics of saline mangrove soils reported in previous years has been continued. The high sulphur content of such soils is their dominant feature, and their future development for rice cultivation will be dependent on a detailed knowledge of their behaviour during reclamation. The work done has therefore been concentrated on this problem.

Practical Aspects of the Development of Saline Mangrove Swamps for Rice Cultivation

In the extension of rice cultivation on mangrove soils in Sierra Leone, the main problem at present is that large areas are excluded from development on account of their permanent salinity. Empoldering of such areas to exclude salt water has not been entirely satisfactory in some cases, owing to the development of highly acid conditions in the soil during the dry season. Three empoldering schemes are being used for rice cultivation at the present time, and observations have been made on their progress in order to help in the formulation of suitable techniques for reclamation.

One of the schemes, which is situated on the Freetown peninsula where there is a shortage of good rice land, has provided an ample demonstration of the effectiveness of good drainage in eliminating the toxic soil conditions which are likely to develop after empoldering. The scheme was constructed in 1944 as an anti-malarial measure and it was not until 1950 that it was possible to install an efficient drainage system. By 1954 a good rice crop was taken from parts of the area and practically

the whole scheme was under successful rice cultivation by the 1955 season. The toxic compounds once present in the soil appear to have been washed out in all parts of the empolder except in one very low-lying area which is still unsuitable for rice cultivation. An experimental plot, which was empoldered at about the same time as the larger area, has been maintained at Rokupr without drainage and is still unsuitable for rice cultivation. From these observations, it is likely that suitable drainage conditions could do much to hasten the recovery of the soil after empoldering. It has been noted that the most persistently toxic areas in the schemes are those which are inadequately drained and low lying. This generalization has been found to be invariably correct, and it would indicate that persistent soil toxicity is the result of the intense reducing conditions which prevail in the badly-drained areas of an empolder during the wet season. Whether the actual toxicity of the soil is due to the large concentrations of iron and aluminium released by the acid formed during the dry season, or whether it is due to the presence of reducing substances such as hydrogen sulphide which is released from the large quantities of sulphate present in the soil at the beginning of the rains, or to both, is not yet established. There is no doubt, however, that persistent unfavourable soil conditions are linked with waterlogging. Under conditions of impeded drainage, the sulphates formed by oxidation during the dry season would be reduced to insoluble sulphides, and thus protected from leaching. The sulphides would remain available for oxidation during the following dry season. The cycle is repeated in subsequent years; inadequate drainage thus perpetuates the nuisance indefinitely.

It has been considered in the past that the liming of mangrove soils would be uneconomic, and this would certainly be so if the farmer had to pay for the lime and set off the value against that of his rice crop. However, as a capital charge, it is probable that the cost of lime would not be excessive compared with the cost of installing and maintaining the empolder, and it would certainly be a fair charge on the reclamation process. The amount of lime required could be cut to a minimum by such measures as closing the bunds when the soil sulphur content was at its lowest, and ensuring maximum drainage of the land at as early a stage in the process as possible, even before the construction of the bund and the clearing of mangrove remains. Experiments with ridge cultivation and transplanting by broadling might also enable the land to be brought under cultivation as quickly as possible. There now seems little doubt that lime must play a part in any major reclamation work to be contemplated in the future, but it is hoped to minimize the cost by determining which conditions will hasten the natural recovery of the soil. It is with this end in mind that the investigations of the characteristics of mangrove swamp soils are being carried out, though it will not be possible to work out full details until a pilot scheme is available for study.

Routine Investigations of Tidal Rice Soils

It has been previously reported from the results of laboratory studies that the mechanism of acid-formation in mangrove soils is largely bacterial. Efforts have been made to discover whether the increase in acidity which occurs in some soils of Rokupr Farm at the beginning of the dry season is also due to bacteria.

Surface soil samples have been collected at weekly intervals throughout the year from an area of rice land adjacent to the river. The area is freely flooded at high tide and is cultivated and planted regularly in a similar manner to that employed by local farmers. The moisture content

and pH values of the soil were determined and an estimate was made using a dilution technique, of the number of sulphur-oxidizing organisms present in the soil at the time of sampling.

A marked increase in the acidity of the soil occurred during the months of January and February and by the end of February the minimum pH value of 3.5 units had been reached. Except for isolated fluctuations, the pH value of the soil samples remained below 4.0 until the middle of August. During the rainy season a very gradual rise occurred and the maximum value of 6.3 was not reached until the middle of November. Previous work has suggested that pH values of less than 5.0 are harmful to rice growth, but the results of the present investigation do not support this view. Rice was transplanted into the soil when its pH was 3.9 and a permanent pH of 5.0 was not achieved until the beginning of November, when the rice had been growing for three months. The rice crop was satisfactory. It would appear that further investigation into the reasons for rice failure in acid soils might be profitably undertaken.

The increase in soil acidity which occurred during January and February could be correlated with a large increase in the numbers of sulphur-oxidizing bacteria present in the soil. These numbers were lower than, but of the same order of magnitude as, those found in a similar soil allowed to dry in the laboratory. It may be concluded that the bacteria are responsible for acid production in the soil under field conditions.

During the rainy season, fairly large numbers of the organisms were still present. This implies that appreciable sulphur-oxidation was still going on during this period, and the result may explain the very slow rate at which the soil pH increased. The fact that reducing conditions in the soil are not intense may be an important factor in the success of the tidal irrigation system. All the results indicate that the fluctuations in pH which occur in the soils are the result of oxidation and reduction mechanisms and not of transport of acid compounds up and down the soil profile.

Routine Analyses of River Water Samples

The rice lands of the Great Scarcies are irrigated by tidal wash throughout the year. During the dry season the volume of water in the river is much reduced and salt water penetrates the rice-growing area for a considerable distance. Salt concentrations toxic to rice are reached in the soil even as far up-river as Rokupr, which is twenty-five miles from the mouth. In general, salinity on the Scarcies rice lands is not a serious problem owing to the large volume of fresh water which flows down the river during the rainy season. In the lower reaches, however, planting has to be delayed until early September on account of soil salinity, and only short duration varieties can be grown.

The movement of salt water over the tidal rice lands is undoubtedly important in their accumulation of sulphur. As they are continually subjected to leaching by rain and river water, there must be annual loss and corresponding gain of sulphur, in order to account for the regular fluctuations in acidity which have been observed in the soils. The present series of analyses was initiated in order to obtain information on the possible accumulation of sulphur by the soils, from sea water carried up the river. It was also hoped to obtain general information on the movement of salt water which might be useful in the trial of salt tolerant rice varieties.

Samples of surface river water were collected at twenty sites at approximately one mile intervals from the mouth of the river to Rokupr.

The samples were taken weekly throughout the year and the time of sampling was arranged to coincide alternately with high and low tide. Using standard methods, the samples were analysed for chloride and sulphur contents.

The year was generally considered to be exceptional in that salt concentrations were higher than usual. From the results obtained, therefore, it should be possible to predict the maximum salt concentration to be expected at a given site in any year.

The increasing salt concentration at each site followed a sigmoid curve, the rise beginning in mid-December and the maximum being reached towards the end of May, after which the level remained almost constant until mid-June when it fell steeply. The end of August saw the salt concentration reduced to zero throughout the river.

An examination of the chloride : sulphate ratios of the water samples throughout the dry season has revealed that the ratio is normally slightly lower than that found in undiluted sea water. Although this effect may not be significant on account of the small differences involved, the results would be compatible with the leaching of sulphate from the riverain soils. An extremely marked increase in the ratio occurred during late March and early April when the salt content of the river water was rising steeply. The increase in the ratio was due to a decrease in the relative amount of sulphate present in the water and suggests that the sulphate was in some way being taken up by the riverain soils or muds. The effect cannot be accounted for by sulphate reduction unless this occurred in submerged mud or suspended detritus. Direct absorption by the acid soils which are inundated at high spring tides seems a likely explanation, and it is hoped to report on the results of further investigations at a later stage. Meanwhile, the analyses are being continued in order to confirm the effect. Sulphate absorption would certainly provide a link in the chain of events leading to pH fluctuations in tidal mangrove soils. If it can be established definitely that the absorption of sulphate in quantity is restricted to a short period of the year, it would be of obvious advantage to exclude tidal wash during this period from soils undergoing reclamation.

Laboratory Investigations

Previously reported investigations have shown that the oxidation of sulphur compounds in tidal mangrove soils is the result of the activities of the sulphur-oxidizing bacteria. Pure cultures of these bacteria, which have been isolated from the soils under investigation, are proving to be similar to those isolated in other parts of the world. Studies of the effects of various ions on the ability of the bacteria to oxidize sulphur compounds are being carried out, as it is believed that they may be sensitive to certain ions in a similar way to the rice plant. Their susceptibilities in this respect may result in incomplete oxidation of the soil sulphur reserves. It is hoped that the results will be of use in formulating reclamation techniques.

It is likely that the chemical mechanisms by which elemental sulphur—the final source of soil acidity—is formed in the soils are similar to those which have been suggested to occur in some reclaimed soils of the Netherlands. Chemical analyses which have been carried out on samples of drying soil have confirmed certain similarities, but the results are of only a preliminary nature owing to the difficulty involved in the analysis of the different sulphur fractions.

From the data at present available, it seems that the main source of readily oxidizable sulphur in the cultivated rice soils and in the tidal mud is pyrites or possibly some other polysulphide. Monosulphide

sulphur is not present in large enough quantities to account for any more than a fraction of the total acid production, and is in any case readily decomposed on exposure of the soil to air, probably being transformed to elemental sulphur. The presence of elemental sulphur in fairly large quantities has been indicated, though again there is insufficient available to account for all of the acid. It seems most probable that the elemental sulphur fraction is oxidized by bacteria, thus lowering the pH and allowing more rapid chemical decomposition of the polysulphide sulphur. These suppositions are in agreement with those put forward by the Dutch in their studies of the soils of the Zuyder Zee. The work is being continued and will be reported more fully at a later stage.

APPENDIX

METEOROLOGICAL RECORDS ROKUPR—1957

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Rainfall (20 year average)	0-00 (0-13)	0-00 (0-05)	0-00 (0-42)	2-58 (1-86)	1-54 (6-80)	11-78 (14-18)	34-65 (23-23)	13-24 (29-38)	20-40 (18-00)	13-21 (15-09)	3-22 (5-52)	0-78 (0-66)	101-40 (115-32)
Sunshine (15 year average)	252-3 (251-0)	224-0 (228-8)	254-7 (241-3)	252-7 (203-7)	205-6 (193-5)	147-7 (160-0)	55-8 (105-9)	114-0 (63-3)	103-8 (128-0)	173-8 (189-0)	206-5 (199-5)	222-1 (224-4)	2213-0 (2188-5)
Mean Maximum Temperature (15 year average)	89-3 (91-1)	92-1 (93-0)	92-1 (93-3)	92-6 (92-9)	91-6 (91-0)	87-9 (88-2)	82-3 (84-3)	83-8 (81-8)	84-3 (85-4)	86-7 (88-4)	89-0 (89-0)	89-8 (89-5)	88-5 (89-0)
Absolute Maximum Temperature (19 year record)	95 (102)	96 (101)	95 (102)	96 (103)	96 (101)	93 (99)	86 (98)	88 (91)	87 (99)	90 (96)	92 (99)	92 (97)	96 (103)
Mean Minimum Temperature (15 year average)	65-0 (68-3)	68-5 (69-5)	68-6 (71-8)	69-9 (73-2)	71-8 (73-8)	73-1 (72-5)	72-9 (72-1)	72-1 (72-7)	72-9 (72-3)	71-9 (71-8)	71-7 (71-9)	71-4 (69-3)	70-8 (71-6)
Absolute Minimum Temperature (19 year record)	50 (50)	61 (60)	62 (62)	65 (65)	69 (69)	70 (63)	68 (60)	69 (68)	71 (68)	70 (68)	70 (63)	68 (53)	50 (50)
Mean Relative Humidity a.m. (8 year average)	82 (89)	88 (87)	83 (84)	78 (83)	78 (85)	86 (90)	94 (92)	92 (93)	91 (92)	88 (89)	87 (89)	89 (88)	88 (88)
Maximum Relative Humidity a.m. (9 year record)	100 (100)	95 (100)	91 (100)	86 (100)	95 (100)	95 (100)	100 (100)	100 (100)	100 (100)	96 (100)	95 (100)	96 (100)	100 (100)
Mean Relative Humidity p.m. (8 year average)	42 (55)	45 (48)	54 (52)	53 (62)	57 (66)	72 (73)	87 (80)	78 (84)	79 (80)	73 (71)	68 (68)	59 (56)	64 (66)
Minimum Relative Humidity p.m. (9 year record)	16 (16)	14 (14)	23 (23)	31 (31)	31 (31)	54 (54)	68 (59)	62 (53)	61 (51)	60 (41)	48 (40)	41 (10)	14 (10)

Rainfall in inches. Sunshine in hours. Temperature in degrees Fahrenheit. Relative Humidity as percentages. Morning readings taken at 09.00 hours. Afternoon readings taken at 15.00 hours. Bracketed figures are averages and records.

